The Sterilisation of Liquids by Light of very short Wave-length.

DURING the past year several articles have appeared in the *Comptes rendus des Séances de l'Académie des Sciences*, Paris, on the sterilisation of liquids by ultra-violet light. The notes of M. Billon-Daguerre have particularly attracted my attention, since he has endeavoured to utilise the region of the spectrum discovered by Schumann for the sterilisation of water. It is obvious that the question of the transparency of water for light of very short wave-length is important in this connection, and, as there seems to be no data which bears on the matter, I have recently made some experiments.

I used a vacuum grating spectroscope arranged in the same way as when I investigated the transparency of some solid substances. The water was distilled, but without any special precautions, and was enclosed in a cell with fluorite windows. Two of these cells were employed, one giving a water column of half a millimetre, the other giving a millimetre column. With the half-millimetre cell in the light path the spectrum was cut off at λ 1792 (Ångström units), even after a prolonged exposure. It appeared that this limit of the spectrum receded rather slowly toward the red with increase in the thickness of the water column.

As M. Billon-Daguerre wished to use light of very short wave-length, he employed a vacuum tube filled with hydrogen. This substance is known to give a strong spectrum in the region between λ 1650 and λ 1030; it must not be forgotten, however, that no lines can be ascribed to it in the region between λ 2000 and λ 1650. Thus any action due to the radiation from the vacuum tube filled with hydrogen must be confined to a layer of water so thin that light of wave-lengths shorter than λ 1650 can penetrate it. Judging from my experiments, such a layer must be very thin indeed.

Several investigators have used the mercury arc in quartz as a source of light in sterilisation experiments. There are two facts which it may be interesting to mention in this connection. In the first place, fused quartz two millimetres thick is somewhat transparent so far as λ 1500; the transparency falls off rapidly with increasing thickness. In the second place, no lines more refrangible than the strong line at λ 1850 are known in the spectrum of mercury. In this second statement my own observations are confirmed by a recent investigation of Dr. Handke.

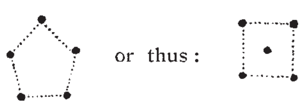
THEODORE LYMAN.

Jefferson Laboratory, Harvard University, July 8.

Elemental Weight Accurately a Function of the Volution of Best Space-symmetry Ratios.

IT is a fact little known, but of the first magnitude, that equal spheres or corpuscles cannot in space, as in one plane, be distributed at equal mutual distances. Tetrahedra, the four points of which alone are all mutually equidistant, cannot be packed so as to fill space, as their face-angles to fill one plane.[1] Icosahedral diffusion, with a central sphere, nearly achieves this, but by a cramping of the central point in the ratio 1 : 1·051460···.

Free magnetic needles in water, say five in number, may fall into position either thus :



Their energies are a fixed quantity; so that, though they will assume either position, they are stabler in position (*a*), because here, on the whole, the lines are more equidistant; but (*b*) might become equally stable if each needle were a vortex possessing an energy v, capable, under heat and cold, of adapting itself to changed environment by cumulative indraught and outdraught, *i.e.* $v^{\pm\frac{n}{m}}$.

In one plane, equal spheres being equitriangularly arranged, each sphere forms a centre capable of supporting, by surface tension, an equal number of spheres around it. In space, the nearest approach to this perfect equilibrium is by means of the five best symmetries, or so-called regular solids, whereof three dominate elemental crystals.[2] Alike as to points, faces, edge-lines, and circum-radial lines, these five contain only the factors 2 and 3 (crystalline) and 5 (non-crystalline), greatly complicated, however, by the last of these :

Crystalline : *hex* $\sqrt{2:1}$; *tet* $\sqrt{8:3}$; *oct* $\sqrt{4:3}$

Non-crystalline : *ic* $\sqrt{2\left(1-\frac{\sqrt{5}}{5}\right)}:1$; *do* $\sqrt{2\left(1-\frac{\sqrt{5}}{3}\right)}:1.$[1]

Now the problem of the volutional interconversion (on the principle $v^{\pm\frac{n}{m}}$) of the three first ratios 2, 3, and 5, yields to a simple and highly accurate solution,[2] whereas adding the two last, *ic* and *do*, the solution becomes complex; but, on the lines of the simple interconversion, there are contained several approximate interconversions with *ic* and *do*, the errors of which are the precise weights of $H^{1 \cdots 4}$ by different syntheses :

$$\left.\begin{matrix} \frac{4}{3} \\ \\ \text{or } oct^2 \\ \text{or } \dfrac{tet^2}{hex^2} \end{matrix}\right\} = \left\{\begin{matrix} \sqrt[12]{2} \\ \text{or } \sqrt[6]{hex} \\ \text{or } ic \times H \text{ (i)} \\ \text{or } \sqrt[7]{\dfrac{hex^2}{oct^2}} \\ \text{or } ic \times H \text{ (ii)} \end{matrix}\right\} \times \left\{\begin{matrix} \sqrt[7]{5} \\ \text{or } \sqrt[7]{3}\, ic \times H^3 \quad \text{(iii)} \\ \text{or } \sqrt[7]{2}\, ic^2 \times H^4 \quad \text{(iv)} \\ \text{or } \sqrt[7]{\dfrac{O(=16 \times do^2}{ic^4 \times oct^2}} \quad \text{(v)} \end{matrix}\right.$$

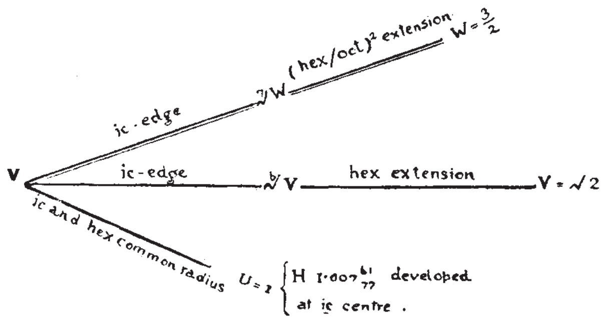
The numbers (i), (ii), (iii), (iv) refer to Morley's four experimental weights of H,[3] which the formula hits precisely :

(i) $H_2 : O$ mean $= 1{\cdot}00761$	(iii) Gravimetry mean $1{\cdot}00762$
(ii) $H_2 : O$ max. $= 1{\cdot}00777$	(iv) $H_2 : H_2O$,, $1{\cdot}00765$

Two basal equations are here involved,

$$(4/3)^x = 2^{\frac{x}{12}} \times 5^{\frac{x}{7}} \text{ and } 2^x(5/4)^{7x} = 3^{2x} \times 1{\cdot}5^{\frac{x}{7}} —$$

7 and 12 being severally the combinable group and series numbers of the table. The main equation (*threes* strong) appears accurate to some 50 decimal points; the secondary (*fives* strong) rather less so. They meet at $\sqrt[7]{1{\cdot}5} = \sqrt[12]{2}$; with an error of 0·00016, the crux of the hydrogen ranges. Their great accuracy points to a profound numeric and geometric principle. *Hex, hex²/oct², &c., compensation-vortices cannot evolve to their 6th and 9th roots without developing hydrogen, and thereupon compensating* ic, *&c.; and, inversely,* ic, *&c., cannot involve to their 6th and 7th powers without ultimately throwing off hydrogen and compensating hex, hex²/oct², &c.*



(i) The compensation-vortex at the end of the cubic (or tet/oct) edge-line, pulls, as required, by $\sqrt{2}:1$ against the circum-cube radius. This crystalline symmetry being disturbed by heat, the vortex unravels or evolves to its 6th root, travelling down the line to the point marked $\sqrt[6]{v}$. It there precisely compensates the *icosahedral edge : circum-*

[1] See Barlow and Pope, Chemical Society Transactions, 1907, vol. xci., p. 1152. [2] Retgers, Zeitsch. physical Chem., 1894, xiv., 1.

[1] *Tet, hex, oct, ic*, and *do* here stand for the ratios, or the weights compensating the ratios, *edge-line* : *circum-radius* (*i.e.* the radius of a circumscribed sphere) severally of the regular tetrahedon, cube, octahedron, icosahedron and dodecahedron.

[2] A log-algebraic problem of eight terms unknown, it was soluble only by reference to philosophical considerations anterior to those now discussed.

[3] Morley, confirmed by Thomsen, Keiser, Guye and Mallet. See International Committee's Report, *Chemical News*, February 12, 1897, May 5, 1899, June 11, 1897, and May 12, 1905; or Freund's "Chemical Composition," 1904, p. 220.

radius ratio; but so that there is developed at the icosahedral centre, a deficit or gravitative pull equal exactly to the hydrogen mean weight by $H_2 : O$, viz. 1·00761.

$$ic = 2^{\frac{1}{12}} [= 1·059462 \cdot\cdot] \div 1·00761.$$

(ii) The vortex compensating the ratio of cube-edge to octahedral-edge—*i.e.* $hex^2 : oct^2$—both having a common or equal circum-radius, unravels down the cube-edge to its 7th root, and at $\sqrt[7]{w}$ becomes an icosahedral compensation vortex; the octahedral-edge becomes or equals the icosahedral circum-radius; and the hydrogen pull is developed at the icosahedral centre; but at $H_2 : O$ max. 1·00777. Cases (iii), (iv), and (v), and all the coalition permutations (see below), are to be interpreted like (i) and (ii), though more complex.

In cases (i), (ii), (iii), and (iv) we have severally $H^{1 \cdot\cdot 4}$; and, similarly, in the coalition formulæ *ic* or H are never in excess by more than the valency numbers 1 to 4 —1 to 8 in the cross-formula (No. 4).[1] This, probably, is attributable to the multiple radial lines. For we are concerned with powers, not multiples. Each central vortex does not need to pull against the sum of all its surrounding vortices as isolated units, because these latter too are themselves centres, and correspondingly weakened. The contraction of the crystalline ratios under heat is consistent with the entropic or adiabatic phenomena of H_2O; and for many reasons it is believed that the weight deviations are a function of entropy. When (see below) the line is crossed, the signs change, contraction becomes expansion, and along the lines of the *pari passu* increase of exponents, the VD, entropically disturbed, gradually becomes constant.

Morley's ranges are severally ±0·00016, ±0·00033, ±0·0007, and (*means*) 0·00004. By coalition of the fractures of the main formulæ, we derive the following, *in all which formulae, $\pm x$ being high, the mean is attained, and the maxima and minima when $\pm x$ is low; so that the formulae can never transcend the experimental range, and always tend to its means.* (Compare entropy):—

Formula		x high	Range
(1) $5/2^{\frac{27-x}{12}}$	$= ic^{x+1} \times H^x$	H = 1·00761	±0·00033
$2^{\frac{28+x}{12}}/5$	$= ic^x \times H^{x+1}$		±0·00016*
(2) $3^{\frac{4}{7}}/2^{\frac{10-x}{12}}$	$= ic^{x+1} \times H^x$	H = 1·00761	±0·00004
$2^{\frac{11+x}{12}}/3^{\frac{4}{7}}$	$= ic^x \times H^{x+1}$		
(3) $5/2^{\frac{17-x}{12}} \times 3^{\frac{4}{7}}$	$= (ic \times H)^x$	H = 1·00761	±0·00030
$2^{\frac{17+x}{12}} \times 3^{\frac{4}{7}}/5$	$= (ic \times H)^x$		
(4) $5^{\frac{3}{7}}/2^{\frac{12-x}{12}}$	$= ic^{x+1}/ H^{7-x}$	H = 1·00761	±0·0005
(5) $2^{\frac{6 \pm x}{7}}/3^{\frac{3 \pm x}{7}}$	$= ic^{2 \mp x} \times H^{3 \mp x}$	H = 1·00777	±0·00015
(6) $5^{\frac{6 \mp x}{7}}/2^{\frac{13 \mp x}{7}}$	$= ic^{2 \mp 2x}/ H^{1 \pm 4x}$	H = 1·00765	±0·00017
(7) $5^{\frac{6}{7}}/2^{\frac{7+x}{7}} \times 3^{\frac{3-x}{7}}$	$= ic^{4+x} \times H^{2+x}$	H = 1·00777	±0·00033
(8) $5^{\frac{6+x}{7}}/2 \times 3^{\frac{3+x}{7}}$	$= ic^{4+x} \times H^{2+3x}$	H = 1·00762	±0·00020

* $x = 2$.

A comprehensive deduction from the general formula is the following:

$$H\,(1·00761) \times \frac{do^2}{ic^3} = \frac{oct\ 4^2}{hex\ 3^2} = \frac{tet\ 4^2}{hex\ 5^2}, \text{ \&c.}$$

Provisionally, upon examination of four out of the eight combinable groups, the elemental weights are found expressible in like terms to these, *i.e. the elemental weights are such that, multiplied into the simple volution of one or more of the symmetry line-ratios, they yield accurately the simple volution of one or more other symmetry line-ratios, each expression having its exact equational variant, like elements yielding to like expression, but not mechanically so* (see *Chem. News*, April 22, May 6, and June 10). This is deduced from the basal-equations with x as $1 \cdot\cdot 8$, the formula not being constructed (or rather discovered) empirically to yield any given weight, but rationally to meet the whole problem of weight compensation. That, x being 1, the H weights were with perfect exactitude obtained, chanced to be a fact almost the last discovered.

Considering the hydrogen solution alone, the rational postulate of vortex compensation for inequidistance (as contrasted with the crude Democritan hard-atom hypothesis) hits precisely—with the odds 100,000 to 1 against each hit—in the four corners of the basal-equation, the four means of hydrogen; and by coalition, all their deviations. *The postulate is thus, on the one element, proved true by the odds* $100{,}000^4$ (10^{20}) *to* 1.

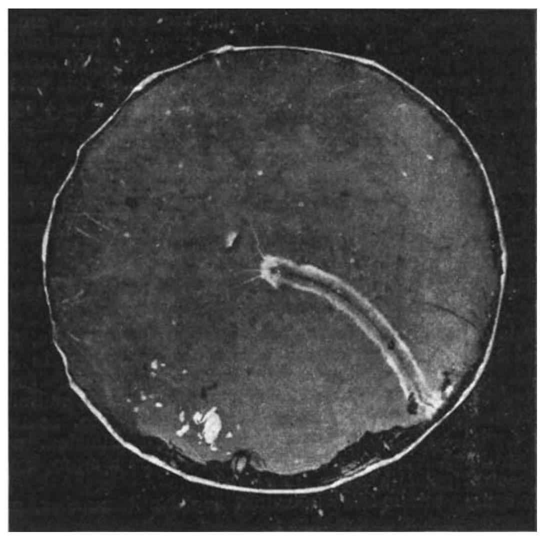
Corroboration is glimpsed in the spectrum-line ratios.

H. NEWMAN HOWARD.

[1] $H^{1 \cdot\cdot 4}$+0, 1, 2, 3 are virtually $H_{1 \cdot\cdot 4}$.

Electrical Discharge Figures.

MR. A. W. PORTER gave in NATURE of March 31 (vol. lxxxiii., p. 142) an account of his experiments on electric discharges over photographic plates, made in order to ascertain what is due to the luminosity of the discharge and what to the discharge itself. Knowing that the disruptive discharge carries metallic particles from the electrodes, and that in the silvering of mirrors by the wet processes the silver begins to set at every metallic particle which clings to the surface of the glass because of the action of local couples, I ventured to develop the invisible image of the discharge on a clean glass plate by the silvering solution.



Electrical discharge figure developed by wet silvering process.

The effect was a very striking one; instead of the broad band of the trunk discharge, a clean band was left, surrounded by two sharp, dense lines of deposited silver. The thin ramifications were still visible, but the splendid display of surrounding figures is lacking. The two unsatisfactory paper prints that I send [one is here reproduced] were made from developed plates, and are therefore negatives. It is impossible to get better results now, because the laboratory is closed for the summer holidays.

The acid intensifier for the collodion plates, acting in the same way as the wet silvering mixture, was also tried by me, but the result was worse.

W. LERMANTOFF.

University of St. Petersburg, Russia.